

## CHAPTER II

### EVALUATION OF TECHNIQUES

## A. GENERAL

Aerial reconnaissance is the only method available which provides sufficient data for the proper analysis of a tropical system. Land stations in the Tropical Pacific are widely scattered and ship reports are concentrated along the shipping lanes which do not generally pass through areas of formation and development of tropical systems. Since most of the ships which are near developing systems take evasive action as soon as the first warning is issued, surface data is generally sparse in the vicinity of a typhoon. Aerial reconnaissance, being mobile, provides the position, intensity, indications of past movement, significant features such as eye shape, size and slope, and any changes which occur while the aircraft is near the storm. By using dropsondes, the reconnaissance aircraft are able to obtain the lapse rate profile to the surface, sea level pressure, and surface temperature and dew point at any point.

The accuracy of warnings is directly related to the quality and quantity of aircraft reconnaissance of tropical systems. Continuous surveillance is required on all tropical systems so that initial warnings may be issued in time to insure proper preparations for safeguarding life and property. In the future, part of this early surveillance may be covered by use of satellites equipped with Automatic Picture Transmission. (APT)

## B. SURVEILLANCE METHODS

During 1964, two aircraft squadrons were assigned the primary responsibility for tropical reconnaissance under requirements of the Joint Typhoon Warning Center, Guam. These units were the U. S. Navy Airborne Early Warning Squadron One (VW-1) which is based at Naval Air Station, Agana, Guam, and the U. S. Air Force 54th Weather Reconnaissance Squadron (54WRS) which is based at Andersen AFB, Guam.

The U. S. Air Force 56th Weather Reconnaissance Squadron (56WRS) based at Yokota Air Base, Japan is the primary backup for the 54WRS and provided all low level fixes assigned the 54WRS during 1964. The U. S. Air Force 315th Air Division based at Tachikawa Air Base, Japan was the normal CINCPACAF theater air backup.

The aircraft used by the various squadrons were the EC121K Warning Star by VW-1, the WB-47 Stratojet by 54WRS, and the WB-50 by the 56WRS.

Land radar was utilized as a backup for aerial reconnaissance when a tropical system was within radar range. This information was available from various weather radar and tactical radar sites.

TIROS and NIMBUS satellite reports were utilized during the 1964 season and were especially useful to JTWC in locating areas of possible storm formation. The APT system was installed during the year, and was used for 10 days during the operational life of the NIMBUS system in September, 1964.

### C. EVALUATION OF AERIAL RECONNAISSANCE

During the 1964 season four fixes per day were scheduled on all typhoons and at least two fixes per day on all tropical storms. To allow sufficient lead time for aircraft deployment on developing systems, many tropical storms, which were expected to develop into typhoons within 24 hours or were in critical areas, were also scheduled for four fixes per day. Tropical depressions and cyclones were scheduled for one or more fixes per day depending on location and potential. In general, 1500 ft or 700mb fixes were made by VW-1 at 1000Z and 1600Z, and both high level (300mb) and low level (700mb) fixes were made by the 54WRS and the 56WRS respectively at 0400Z and 2200Z.

Both VW-1 and 54WRS flew synoptic tracks and investigations throughout the season. The bulk of the synoptic tracks over the Trust Territory islands were covered by 54WRS and most of the investigative flights were handled by VW-1.

In spite of problems associated with higher priority missions, a large percentage of the fixes and investigations requested were completed. VW-1 had an outstanding record for the year, with only one requirement not met out of 318 fixes and investigations requested. 54WRS made 192 fixes and investigations with 20 requirements not met, and 56WRS made 263 fixes and investigations with 25 requirements not met.

1964 was the first full season of reconnaissance for the WB-47 aircraft of the 54WRS. It was found that these aircraft could give good radar coverage of any storm which had developed enough to produce a radar picture. In addition, visual reports were obtained when cirrus or middle clouds did not obscure the lower clouds and it was possible in some cases to detect areas of surface calm by the change in the radar "Sea return". In addition, the 300mb doppler winds and temperatures were a valuable addition to the analysis at that level, and amazingly accurate surface wind estimates were obtained when the sea surface was visible. However, since the WB-47 dropsonde system was inoperative throughout the season, no other lower level data was obtained. Other problems encountered were inability to hold station on a storm under most circumstances, and limited range. Also, a blackout of communications occurred whenever the aircraft passed through a cloud. Since most penetrations of mature storms were made through the cirrus cap this meant a delay in receipt of the eye report itself.

During 1964 a VW-1 aircraft established a record by making four fixes on one flight. During the time Typhoons Kathy and Marie were both east of Okinawa the storms were close enough to each other to be both held on radar at the same time. By taking station between the storms and making one fix 30 minutes early and the other 30 minutes late one aircraft was able to move close enough to each in turn for an accurate radar fix.

#### D. EVALUATION OF DATA

##### 1. Aerial reconnaissance data

Aerial reconnaissance data can be divided into three categories, peripheral, eye data from penetration, and eye data from radar.

Peripheral data is all information reported enroute to a storm and outside the eye of the storm. It includes weather, clouds, flight altitude wind, temperature and dew point, and surface wind if the sea surface is visible. Dropsonde data is also provided by WB-50 aircraft and occasionally by EC121K aircraft, giving lapse rate below the aircraft, surface temperature, pressure and dew point, and the height, temperature and

dew point of standard levels below the aircraft. This same type of data is provided on all synoptic tracks and special investigations. All peripheral data from WB-47 aircraft is obtained at 300mb, that from WB-50 aircraft is usually from 700mb but may on occasion be from 500mb or 1500 ft. EC121K aircraft usually fly at 700mb or 1500 ft. unless flight over mountainous islands requires flight at 500mb.

Eye data from penetration includes all information reported in peripheral data plus eye size, shape, description, slope, cloudiness, maximum flight level and surface wind and surge (if any), and any other remarks which might be of help to the forecaster such as feeder band description, present direction and speed of movement of the center, etc. If possible a dropsonde is also made in the eye. If the wind, cloud, pressure and radar eye do not coincide, the type eye reported is specified and bearing and distance given to any others.

Eye data from radar provides a description of the radar eye and its location, including description of spiral bands and height of wall clouds. Also included is the aircraft position at the time the radar observation is taken, and maximum observed winds if possible.

On all eye messages an estimate of the accuracy of the fix and a statement of the type of navigation fix used by the aircraft were given. These were used as a guide by JTWC in estimating fix accuracy, but it is felt that they were more representative of the accuracy of the aircraft position than that of the typhoon eye, especially with radar fixes from a considerable distance, where attenuation can distort the radar image considerably.

During 1964, daylight penetration of typhoons was accomplished on all but a few of the most severe storms by WB-50 aircraft, with daylight overflights on most storms by WB-47 aircraft. When possible, EC121K aircraft also penetrated the storms, largely on daylight or evening fixes, but often also on nighttime fixes.

The data obtained by the various squadrons was good with a very few exceptions. Crew experience varied widely through all

the squadrons, with enough "old hands" carried over from the 1963 season at VW-1 and 56WRS to train the newcomers. Due to the phase-in of a new aircraft, crew experience in typhoon work was low in the 54WRS early in the year. However, due to an aggressive training program, there was a rapid increase in effectiveness through the season. One difficulty faced by all three squadrons was that of obtaining good navigational fixes in those areas where loran navigation is poor. The opening of additional loran stations should help this problem.

SUMMARY OF RECON ERROR FOR 1964  
(Vector Error of Fix from Best Track)

	<u>54WRS</u>	<u>56WRS</u>	<u>VW-1</u>
As Tropical Depression	29 MI*	17 MI	15 MI
As Tropical Storm	29 MI*	16 MI	19 MI
As Typhoon Only	11 MI	08 MI	08 MI
For All Fixes	16 MI	11 MI	12 MI

Average for the year for all fixes for all squadrons= 12 MI

\* This table does not include several cases in which tropical systems were located on pressure profile by low level aircraft and could not be located at all by WB-47 aircraft.

The information received from all reconnaissance aircraft was continually checked for consistency and accuracy. Where possible, JTWC graphs and other aids were used to check for continuity with previous reports. Any apparent discrepancy was checked with the observing aircraft when possible.

## 2. Land Radar

Land radar reports were used in conjunction with aircraft reports whenever possible. These reports included range and bearing of the eye from the station, eye characteristics and occasionally direction and speed of movement of the eye. A combination of attenuation, operator inexperience, and the fact

that the radar could "see" only the top of the storm made distant land radar reports often inaccurate. However, as the storm approached the station, the accuracy usually improved markedly.

### 3. Satellite Reports

Miscellaneous satellite bulletins giving information on tropical systems were received periodically throughout the season. While many of these bulletins provided only a verification of past fixes, on a few occasions they were very useful as the basis for scheduling investigative missions, and led indirectly to the location of several tropical storms. These bulletins could be much more useful to JTWC if their receipt was more timely.

Due to the small time lag involved, the APT system was very useful during its brief life. Typhoon TILDA developed northwest of Guam during this period, and was picked up as a "comma configuration" on APT pictures over 24 hours before it reached the tropical storm stage. APT satellite pictures, if regularly received, would reduce the need for synoptic tracks and investigative missions, and with a backlog of interpretive experience, would eventually cut down the number of fixes needed on developed tropical storms.

### E. COMMUNICATIONS

Radiotelegraph (CW) is the primary means of communication between the ground and aircraft for VW-1 and 56WRS. For the WB-47's of 54WRS, the primary contact is by voice broadcast. For all aircraft, AIE-2, Andersen AFB, Guam, is the primary air-ground contact, with AIF-8, Yokota AB, Japan, and AIC-2, Clark AB, Republic of the Philippines, secondary stations. In all cases AIE-2 is responsible for relay of reports to JTWC via local circuit 3L28. This circuit also serves VW-1 and 54WRS.

When aircraft were in contact with AIE-2, most reports were received in JTWC in sufficient time to enable the forecaster to make a comprehensive study of the data before warning time. However, when the aircraft was working secondary stations, the reports were quite frequently unavailable at JTWC before warning time, and had to be tracked down by the forecaster through use of long distance telephone links or "wirenotes." This was

especially true of AIC-2, where the use of regular AIROPNET messages often led to a delay of up to 24 hours in time of receipt. This situation was encountered with practically all fixes in the South China Sea, and without the use of Fleet Weather Facility, Sangley Point as an alternate relay point, it would have been even more of a problem. It is hoped that the establishment of a cable connection between Guam and the Philippines will help reduce this problem.

#### F. SUMMARY OF RECONNAISSANCE SUPPORT

A summary of the aircraft reconnaissance support provided during 1964 as well as a comparison of reconnaissance provided in recent years is shown in the following table:

1964 AIRCRAFT RECONNAISSANCE DATA

UNIT	<u>TROPICAL CYCLONES (52)</u>			<u>SYNOPTIC TRACKS</u>
	<u>NO. OF</u> <u>SORTIES</u>	<u>NO. OF FIXES/</u> <u>INVESTIGATIONS</u>	<u>BONUS</u>	<u>NO. OF</u> <u>SORTIES</u>
VW-1	238	317	16	114
54WRS	192	192	6	218
56WRS	186	263	11	2
OTHER USAF	-	-	2	-
CIVILIAN	-	-	1	-
TOTALS				
1964	616	772	36	334
1963	356	465	8	170
1962	373	496	10	126
1961	304	350	27	---

#### G. EVALUATION OF NUMERICAL WEATHER PRODUCTS

During 1964 operational steering forecasts based on numerical prognoses were received at JTWC from the Fleet Numerical Weather Facility (FNWF) Monterey, California and

occasionally from the National Meteorological Center (NMC), Suitland, Maryland. Due to the proximity of most typhoon tracks to the boundary of the NMC grid, the NMC forecasts were of limited use. However, on storms which moved well north of Guam, the NMC forecast was compared with the FNWF product.

Operational steering predictions were furnished by FNWF on 40 storms during 1964. According to verification performed by FNWF "Average errors were comparable to the previous season's experience; however, the JTWC Guam forecasts as issued showed significantly lower error than the numerical product on which they were based contrary to previous experience."

For the 1965 season FNWF plans to make further refinements in the steering computations using three different steering levels. These refinements combined with greater familiarity with the possible errors inherent in the system should lead to increased forecast accuracy in 1965.

#### H. EVALUATION OF OPERATIONAL FORECAST PROCEDURES

The basic forecasting technique used throughout the 1964 season was a subjective modification of the numerical steering prediction. Modifications were based on climatology (see Chapter I), and subjective evaluation of micro-analyzed 700, 500, 300 and 200mb charts, with emphasis on the 700mb chart.

In all cases the steering forecast was first checked for abnormal cyclonic curvature, since the steering model used in 1964 did not remove the storm circulation successfully on large storms. If the steering forecast looked reasonable from this standpoint, it was then checked for consistency with climatology and past history. Finally the upper air charts were checked for areas of maximum divergence, areas offering the least resistance to the forward motion of the storm and the 700mb height criteria of Wang.

A subjective integration of all the factors listed above was then used to establish or modify the forecast track of the system. Speed of movement was then forecast from history, climatology, and the steering forecast.

It is felt that this subjective modification of the numerical product is at present superior to any available regression type forecast and offers the best hope for improved typhoon forecasting. In all tests made by this organization the present system has consistently beaten all objective techniques. As further experience is developed in the interpretation of numerical forecasts the accuracy of this type of forecast should improve considerably.